Impact of Urban Sprawl on Travel Behaviors and Local Watersheds in the Auburn–Opelika Metropolitan Area: A Case Study on a Small MSA

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Abstract:

Urban sprawl bas been a major policy issue for some time in academia as well as in American politics because it has a significant impact on environmental characteristics of urban areas. Among others, it consumes large amounts of agricultural and forested lands, increases congestion, travel time and air pollution, and misallocates land resources. It also discourages development of public transportation as infrastructure costs become higher in scattered developments, resulting in inefficient use of energy. Most attention in the USA has been given to large cities because it is assumed that sprawl is only a phenomenon of the larger metropolitan areas. However, urban sprawl is a growing problem in smaller communities as well (Weber and Maret, 2003). This study examines a relatively small Metropolitan Statistical Area (MSA), Auburn-Opelika, Alabama (population 115,092) by using the most recent Census Population and Housing Summary File 3 (STF 3) data and a geographic information system (GIS) technique to determine the potential impacts of urban sprawl on travel behaviors of the local population and its growing pressure on local watersheds over the period 1990-2000. Our measure of urban sprawl suggests that the urban growth pattern over the last decade has been more towards sprawl than the local planning commission's claim of smart growth. This sprawl like growth pattern over the last decade has increased commuting times for Auburn-Opelika residents. and furthermore, associated land use changes have increased pressure on local watersheds. This research implies that small MSAs should no longer be excluded from the discussion of potential impacts of urban sprawl in the US.

Keywords: urban sprawl | watershed | Auburn-Opelika | MSA

Article:

1. INTRODUCTION

Urban sprawl bas been a major policy issue for some time in academia as well as in American politics because it has a significant impact on environmental characteristics of urban areas. Among others, it consumes large amounts of agricultural and forested lands, increases congestion, travel time and air pollution, and misallocates land resources. It also discourages development of public transportation as infrastructure costs become higher in scattered developments, resulting in inefficient use of energy. Most attention in the USA has been given to large cities because it is assumed that sprawl is only a phenomenon of the larger metropolitan areas. However, urban sprawl is a growing problem in smaller communities as well (Weber and Maret, 2003). This study examines a relatively small Metropolitan Statistical Area (MSA), Auburn-Opelika, Alabama (population 115,092) by using the most recent Census Population and Housing Summary File 3 (STF 3) data and a geographic information system (GIS) technique to determine the potential impacts of urban sprawl on travel behaviors of the local population and its growing pressure on local watersheds over the period 1990-2000. Our measure of urban sprawl suggests that the urban growth pattern over the last decade has been more towards sprawl than the local planning commission's claim of smart growth.[1] This sprawl like growth pattern over the last decade has increased commuting times for Auburn-Opelika residents. and furthermore, associated land use changes have increased pressure on local watersheds. This research implies that small MSAs should no longer be excluded from the discussion of potential impacts of urban sprawl in the US.

2. SPRAWL AS THE CAUSE OF AN UNWANTED EXTERNALITY

Defining sprawl is a difficult task because it connotes many conditions depending on one's experience and point of view (Galster et al., 2000). The most accepted definition of urban sprawl is given by the US Department of Housing and Urban Development as "very low-density settlements, both residential and non-residential; dominance of movement by use of private automobiles, unlimited outward expansion of new subdivisions and leapfrog development of these subdivisions; and segregation of land uses by activity (USHUD, 1999:33)." As a result, it is a pattern and pace of land development in which the rate of land consumption for urban purposes exceeds the rate of population growth. Down (1998) and Galster et al. (2000) viewed sprawl as the cause or unwanted externalities: conversion of farmland to urban uses, high automobile dependence, isolation between jobs and housing locations, and consequently, lengthening commuting times of local residents. For our purpose in this paper, we consider sprawl as a condition where there is urban expansion outside the 1990 census defined Urban Area (UA), based on the changes in population density between 1990 and 2000. Moreover, we are mainly interested in measuring the cost of unwanted externalities of urban sprawl such as commuting time and human pressure on local watersheds. The watershed is used in this study because it is a standard unit of analysis for human impacts on environmental characteristics of the physical landscape such as water quality which affect the quality of urban life and public health.

3. RESEARCH QUESTIONS

The research questions are developed at two phases:

[1] The smart growth plans focus on revising land-use controls, which address the problems of lack of housing diversity, traffic congestion, and environmental degradation. It incorporates the transit-friendly design. These plans concentrate growth in the areas where infrastructure, open space, and social inequity already exist.

1) Measuring the sprawl for the entire metropolitan area of Auburn-Opelika, Alabama and calculating the changes of commuting time for the last decade (1990-2000).

2) Subdividing the locality into watershed boundaries at census defined Auburn-Opelika Urbanized Area (AU) and calculating the human pressure and changes in commuting time within these watersheds between 1990 and 2000.

4. STUDY AREA

The Auburn-Opelika MSA, a newly declared small metropolitan area (census 2000), was used as the study area for this analysis (Figure 1). It consists of only one county, Lee, which had a population of 115,092 in 2000. According to 2000 census data, the metropolitan area grew almost 29 percent from 1990-2000. There had been significant growth in all segments of Lee County during the 1990s (Jackson, 2001). This MSA has embraced some industrial growth during the 1990s and will continue to experience growth as more industries move into the area. However, the majority of the development was more in the peripheral edges of the Urbanized Areas, which causes urban sprawl. For all these reasons, Auburn-Opelika is an ideal case study to examine the changes of urban sprawl and its relationship with the changes of commuting time, the mode of transportation over time and its growing pressure on local watersheds.

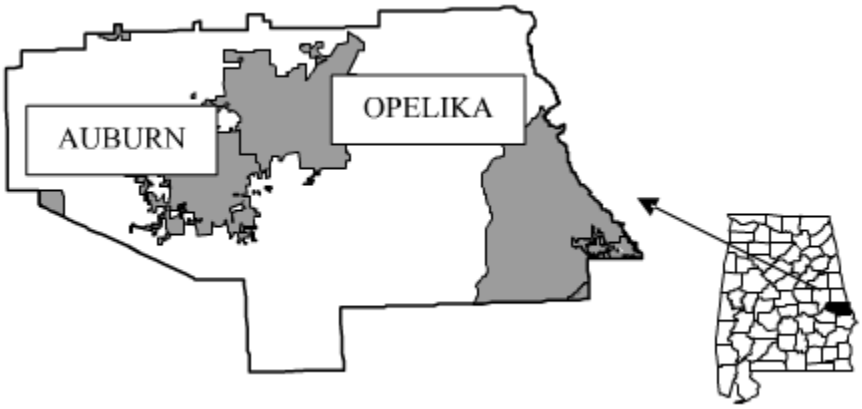

Figure 1. Major Places in Lee County, AL. (Auburn-Opelika MSA)

5. DATA ANO METHODOLOGY

The demographic and journey to work data for this study were collected from U.S. Census Bureau Population and Housing Summary Tape File (STF1 and STF3 for 1990 and 2000). The watershed and landcover data were collected from the United States Geological Survey (USGS, 1999 and 2000). The census defined block and block group geographic shape files were collected from ESRI (2001a, b).

Population density changes per sq. mile for each block group were used to measure sprawl. Census Transportation Planning Package data are the best resolution data for journey-to-work research; however, those data were not available for 2000. Therefore, Census block group data were used for this study for the journey-to-work statistics. Geolytics created 1990 boundaries,

which are comparable to 2000 census boundaries, were used to compare the changes in population density and commuting time by block group between 1990 and 2000 (Geolytics, 2000). Commuting time was calculated by workers' places of residence, which was the only way to measure it by using STF3 data.

A digital elevation model (USGS, 1999) and a TIGER file of the streams (ESRI, 2001a) were used to create the boundaries of the watersheds in the vicinity of the Auburn-Opelika Urban Area (UA). The data were imported into the ArcView GIS program where the streams were overlayed onto the digital elevation model. Visual inspection was then used to identify the watershed boundaries, which were manually digitized.

The National Land Cover Dataset for 1992 (USGS, 2000) was used to compute the urban land cover for each watershed in 1990 because it provided a reasonable representation of land cover conditions for that time period. The watershed boundaries were then overlayed onto the land cover map to determine the urban land cover area (hectares) within each watershed, and the percentage of each watershed dedicated to urban land cover. Urban land cover data were not available for the 2000 time period, so a simple method based on population change was used to estimate the values. The first step was to overlay the watershed boundaries onto a 1990 TIGER census blocks file (ESRI, 2001a; US Census Bureau, 1991), and then select the blocks that matched the various watersheds based on the "center-of-block" option in ArcView. A ratio of urban land cover (hectares) per person was then computed for each watershed by dividing the urban land cover in each watershed in 1990 by the total population of each watershed in 1990. The TIGER census blocks data for 2000 (ESRI, 2001b; U.S. Census Bureau, 2001a, b) were then used to compute the total population of each watershed in 2000. The urban land cover (hectares) in each watershed in 2000 was then estimated by multiplying the. total population in each watershed in 2000 by the ratio of urban land cover (hectares) per person for each watershed that was computed for the 1990 period. The percentage of each watershed dedicated to urban land cover in 2000 was then computed by dividing the estimated amount of urban land cover (hectares) within each watershed by tbc area of each watershed. The number of workers and their commuting times were calculated at each watershed level as well by using 1990 and 2000 Census Population and Housing Summary Tape File (STF3) block group data.

6. RESULTS AND DISCUSSION

6.1. MEASURING URBAN SPRAWL AND COMMUTING TIME

The changes in population density and commuting time between 1990 and 2000 are shown in Figure 2. As expected, higher increases in population density occurred outside UA and negative to low population density change was found within the UA, especially within the Auburn-Opelika area. In the Auburn-Opelika UA only one block group experienced higher population density change, but this block group was in a peripheral area of this UA. These patterns are to be expected and clearly reveal the nature of sprawl within the MSA. Figure 2 also shows how commuting time has changed over the last decade for each block group. As expected, commuting time has changed for those areas in which new concentrations of population were found. More clearly, commuting time increased in those areas during the 1990s where the most sprawl occurred.

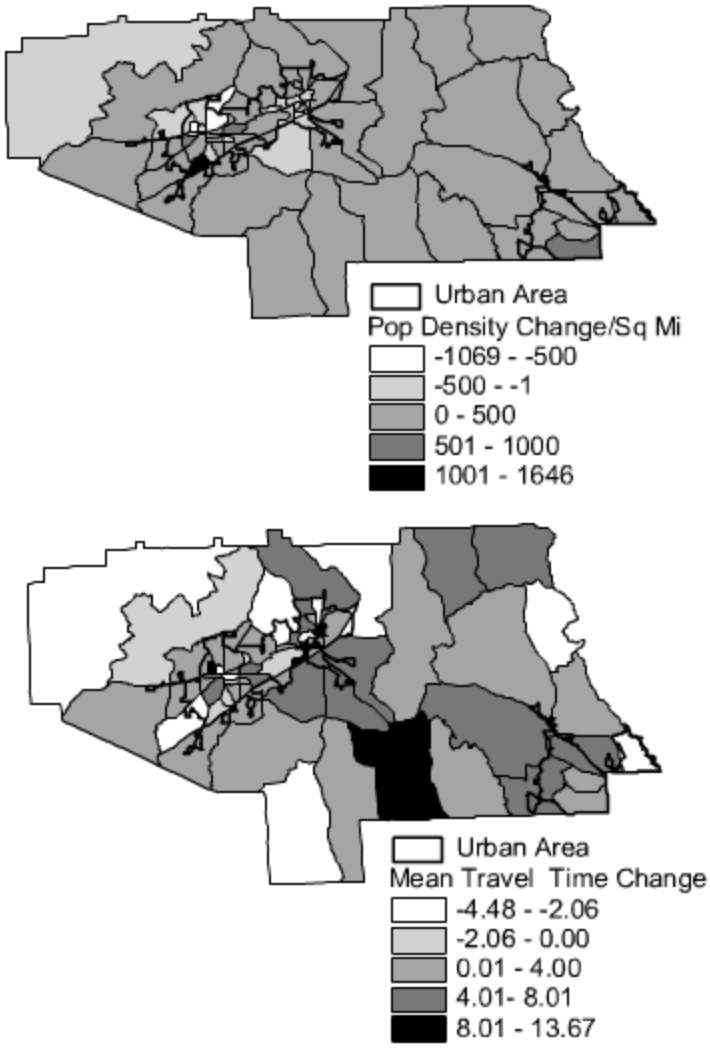

Figure 2. Population Density and Mean Travel Time Change in Auburn-Opelika MSA: 1990-2000

Table 1 also shows the extent to which the negative consequences happened in terms of commuting behaviors because of continual sprawl in 1990s. During the last decade overall commuting time for Auburn-Opelika MSA has increased 3 minutes, which was 17 percent of overall growth. There was a 4 percent increase in workers who drove alone, and there were fewer workers who carpooled in 2000 than in 1990. In 2000, more than 86 percent of commuter trips were made by car, while that number was 81 percent in 1990.

Table 1. Journey to Work Patterns in Auburn-Opelika MSA in 1990 to 2000

Workers Characteristics	**1990**	**2000**	**Percent change from 1990 to 2000**
Total workers who worked outside the home	38329	51189	33.55
Travel Times in Minutes	17.68	20.58	16.44
Percent workers Drove Alone	81.03	85.67	4.64
Percent workers Carpooled	13.22	11.0	-2.22
Percentage of workers who live and work within urban place	65.01	49.02	-16.00
Percentage of workers who live within urban place, but work outside urban place	35.90	50.98	15.00

Table 1 also reveals another important outcome about changes from 1990 to 2000, which was that workers who live and work. within the Urban Place have declined from 65 percent to 49 percent (-16 percent), and workers living within the Urban Place and working outside the Urban Place have increased from 36 percent to 51 percent (+ 15 percent). This result implies an important dimension of urban sprawl. Sprawl encourages non-residential development outside the urban areas resulting in separation between location of jobs and housing. Therefore, this research indicates that sprawl separated the Auburn-Opelika MSA residents from their potential job locations and resulted in longer commuting time, which confirms the important relationship between urban sprawl and commuting time of local residents.

These results are further broken down by commuting duration by workers' place of residence for the year 1990 and 2000 (Figure 3). The comparison between 1990 and 2000 confirms again that overall commuting time for local residents have increased for each category. There was a relatively low share (4.5 percent) of short (0 to 4 minutes) commutes and a relatively high share (75 percent) of 10 to 15 minutes, 15 to 19 minutes, and 20 to 24 minutes commutes in the Auburn-Opelika MSA in 2000. These categories of duration commutes were only made by 55 percent of workers in 1990. There was a substantial change in duration of commute time between 30 to 34 minutes from 1990 (9 percent) to 2000 (16 percent). These results also show that the number of workers who commuted 90 minutes or more in 2000 (5 percent) was considerably higher than in 1990 (0.3 percent). Overall, these findings again suggest that the urban sprawl pattern resulted in increased commuting time for local residents.

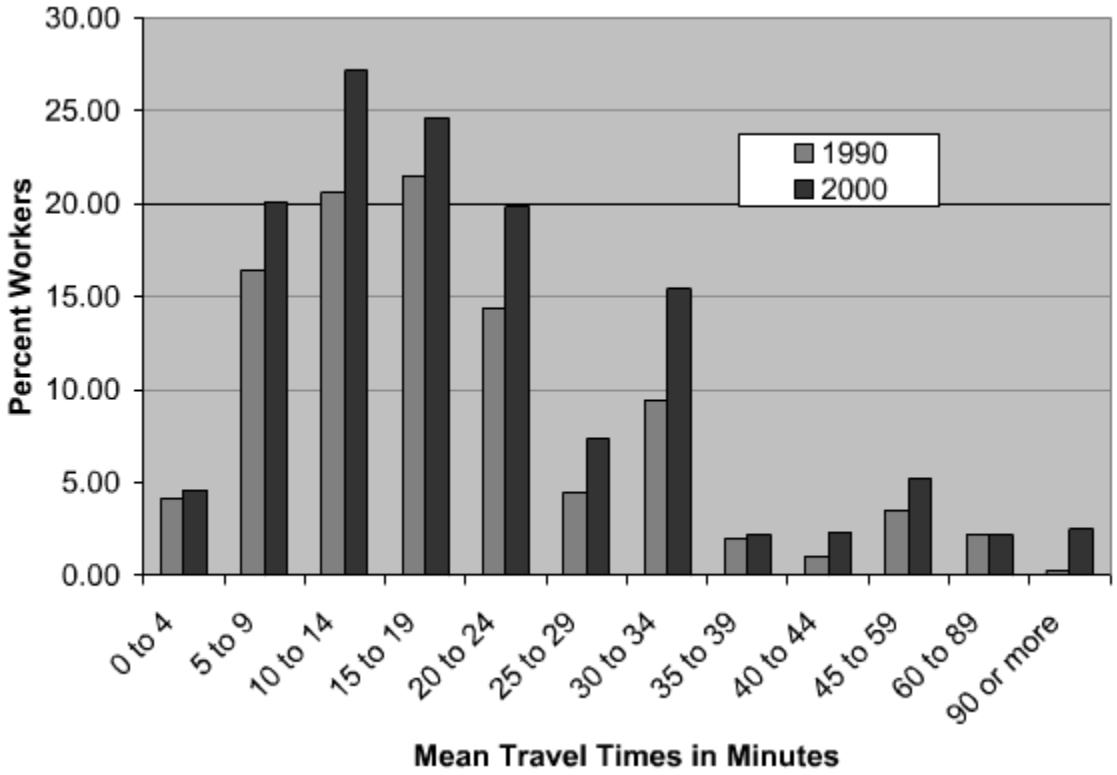

Figure 3. Mean Travel Time by Workers in Auburn-Opelika MSA in 1990 and 2000

Table 2. Percentage of Watershed Dedicated to Urban Landcover

ID	Watershed	1990	2000	Change (+)
1	Loachapoka Creek	6	11	5
2	Country Club Creek	20	33	13
3	Upper Saugahatchee Creek	28	32	4
4	Parkerson Mill Creek	17	22	5
5	Town Creek	31	44	13
6	Moores Mill Creek	10	20	10

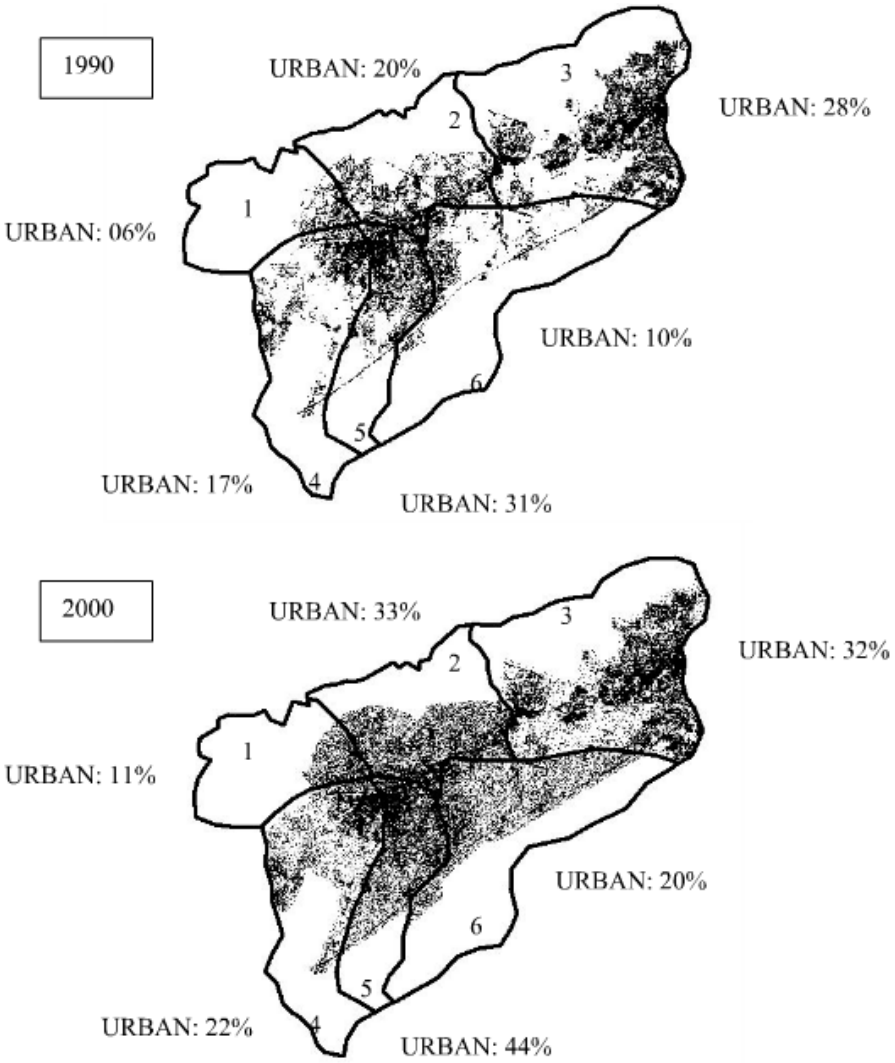

Figure 4. Urban Landcover in Auburn-Opelika Watersheds: 1990-2000

6.2. MEASURING HUMAN PRESSURE AND MEAN COMMUTING TIME AT LOCAL WATERSHEDS

The results of the urban land cover analysis for the watersheds in the Auburn-Opelika area indicated that the two watersheds with the highest percentage of urban landcover in 1990 were Town Creek (31 percent) and Upper Saugahatchee Creek (28 percent), and that the watershed with the lowest percentage was Loachapoka Creek (6 percent) (Table 2 and Figure 4). In 2000,

the two watersheds with the highest percentage of urban land cover were Town Creek (44 percent) and Country Club Creek (33 percent), and the watershed with the lowest percentage was Loachapoka Creek (11 percent). More importantly, the watersheds that experienced the highest amount of change from 1990-2000 were Town Creek (+ 13 percent), Country Club Creek (+ 13 percent), and Moores Mill Creek (+10 percent).

Workers commuting times are also aggregated by each watershed areas (Table 3). The results give a very interesting outlook about commuting behavior of local communities. While Town Creek and Country Club creek experienced the most human pressure, the average commuting times for these residences remain the. same for the last decade. In fact, residents in Town Creek watershed area commute a little less in 2000 than they did in 1990. Town Creek and Country Club Creek watersheds are highly built areas and these finding suggest that travel time decreases as density of urban development increases. Conversely, Loachapoka watershed area had the highest commuting time in 2000 (21 minutes in 2000 compared to 16 minutes in 1990) and had the lowest level of urban growth. Overall, commuting time for all the other watershed areas has increased approximately 3 to 5 minutes from 1990 to 2000. In addition, percentage of solo commuters increased and percentage of carpool commuters decreased in the last decade in every watershed except Loachapoka Creek watershed area. The highest number of workers who drove alone is in Moores Mill Creek watershed area. These findings suggest that an increase in the density of urban development will lead to more balance between jobs and housing, less commuting time, and less dependence on automobiles.

Table 3. Travel Behaviors of Workers at Watershed Level, 1990 to 2000

Watershed	1990			2000		
	Mean Travel Time	Percent Drove Alone	Percent Carpooled	Mean Travel Time	Percent Drove Alone	Percent Carpooled
Loachapoka Creek	15.84	83.18	13.04	20.87	75.97	21.53
Country Club Creek	14.77	83.95	11.81	15.79	86.49	9.91
Upper Saugahatchee Creek	14.07	79.13	17.06	17.19	87.87	9.21
Parkerson Mill Creek	11.28	48.85	8.53	15.26	71.42	9.67
Town Creek	13.77	76.86	9.85	13.30	82.97	7.81
Moores Mill Creek	14.31	87.84	9.63	17.79	91.26	6.17

Consequently, these findings could also suggest that the Town Creek, Country Club Creek, and Moores Mill Creek watersheds experienced a more rapid increase in "human pressure" than the other watersheds. More specifically, the rapid rates of urban development in these areas mean that there was a considerable increase in buildings, roads, and parking lots. These features prevent rainfall from penetrating into the ground by channeling the water into storm drainage systems that dump the runoff directly into local streams. Significant amounts of materials such as automotive oil, gasoline, lawn fertilizers, and sediment (i.e., soil or dirt) are therefore dumped directly into local screams and can significantly degrade water quality. Furthermore, channeling rainfall water into storm drainage systems and then dumping it directly into local streams greatly enhances the potential for flash flooding. Therefore, the potential for water degradation and flash flooding are increasing at a more rapid rate in Town Creek, Country Club Creek, and Upper Saugahatchee Creek watersheds as a result of increased "human pressure."

7. CONCLUSION

Most attention in the USA has been given to the large cities because it is assumed that sprawl is only a phenomenon of the larger metropolitan areas. However, urban sprawl is a growing problem in smaller communities as well (Weber and Maret, 2003). This research provided an opportunity to assess the impact of sprawl on commuting behavior of the local population of a small MSA such as Auburn-Opelika and its growing pressure on local watersheds over the period 1990-2000. In the recent decade, Auburn-Opelika MSA has been experiencing industrial growth which is expected to continue in the near future. To provide housing, roads, schools, services and parks for this growing population, new developments will be taking place. Our measure of urban sprawl suggests 1hat the urban growth pattern over the last decade has been more towards sprawl (toward peripheral area of the Urban Area). This sprawl like growth pattern over the last decade has increased commuting times for Auburn-Opelika residents, and furthermore, associated land use changes have increased pressure on local watersheds. The findings of this case study indicate that small MSAs should no longer be excluded from the discussion of potential impacts of urban sprawl in the US.

Growth itself cannot be discouraged; however, sprawl should be discouraged, and it is a major geographical concern. The open space retained today must be conserved and used wisely in the future in order to sustain a growing population. This is why designing within an ecological framework will become the basis and challenge of future planning issues. To ensure this framework, a policy strategy should be strictly focused on smart growth patterns that consider both urban development and watershed health issues, and a sense of balanced community should be encouraged.

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